CONTROL SYSTEM FOR AN AGILE OPTICAL NETWORK

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] This is the first application filed for the present invention.

MICROFICHE APPENDIX

[0002] Not Applicable.

TECHNICAL FIELD

[0003] The present invention relates in general to routing in optical networks, and, in particular, to a method and apparatus for permitting efficient dynamic routing in wavelength division multiplexing (WDM) networks using rules abstracted from physical propagation constraints in the WDM network.

BACKGROUND OF THE INVENTION

[0004] Many wavelength division multiplexing (WDM) optical networks now leverage signal propagation techniques that permit a distance between regeneration of optical signals to be extended beyond a single optical fiber link in a legacy optical network. Consequently electrical switches that perform optical-electrical-optical (OEO) conversions to regenerate optical signals, and route optical signals on respective optical fiber links, become redundant for at least certain channels. Given the space and power consumption of equipment required to perform OEO conversions, the complexity and transmission delays that OEO conversion incurs, and the high capacity of optical fiber, it is recognized that overlaying electrical switches with all-optical switches permits more efficient use of

network resources. The all-optical switches perform wavelength selective switching, permitting the independent routing of each wavelength in a WDM optical fiber. Wavelengths can be "added" or "dropped" by the all-optical switches. The dropped wavelengths can be routed to a subtending electrical switch. The electrical switch performs OE conversion, and switches the converted signal received on a dropped wavelength to at least one output port. The output port may support a connection to a terminal or other network equipment, or it may be an optical transmission port adapted to perform EO conversion, and thus be connected to an optical fiber link. If the optical fiber link is connected to the all-optical switch, the subtending electrical switch can be used to regenerate the dropped wavelength using the OEO conversion capabilities of the electrical switch.

[0005] There are a number of challenges raised by network routing in this kind of WDM optical network. United States Patent Number 6,215,763 B1, entitled MULTI-PHASE PROCESS FOR DISTRIBUTED PRE-COMPUTATION OF NETWORK SIGNAL PATHS, which issued to Bharat et al. on April 10, 2001, teaches a two phase method for assigning link capacity to a requested data transport service. A first phase assigns capacity that can be made available without conflicting with existing capacity assignments; and a second phase deals with contention resolution. Although meritorious, this invention bases capacity assignment only on wavelength availability and failure isolation.

[0006] In WDM optical networks that perform all-optical wavelength switching, link capacity allocation is preferably constrained by minimizing the use of drop paths

for regeneration so that communications channels can be maintained for as long as possible in an all-optical domain. Consequently, efficient capacity allocation for one link is dependent on capacity allocation on adjacent links. Efficient allocation of capacity depends on two important factors; capacity available on all wavelengths that may be conveyed through a given link, and the viability of using any one or more of the wavelengths to establish a channel through the network. The viability depends on all of the transmission equipment in each link of a wavelength in the communications channel. Consequently, link allocation should be performed, contrary to the method of Bharat, on a wavelength basis, especially to improve the efficiency of routing in WDM optical networks that perform wavelength selective routing.

[0007] No method for automatic reconfiguration of a WDM optical network is known that specifically takes into consideration the viability of a communications channel. Instead, admission control and network reconfiguration are performed separately. This leads to inefficient routing and network resource utilization. By taking into account link viability, the optical spans of a wavelength can be maximized, resulting in fewer regenerations and cheaper data transport.

[0008] In modern networks that carry mixed traffic, there is frequent demand for network reconfiguration to accommodate fluctuating traffic loads. An agile network that is adopted to autonomously reconfigure is therefore desirable. To be most effective, the agile network must be adapted to reconfigure at the wavelength level in order to provide maximum flexibility.